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REPORT

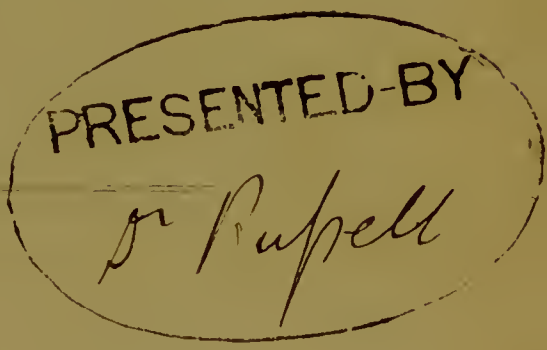
BY

THE DEPUTATION APPOINTED BY THE TOWN COUNCIL AND BOARD OF POLICE OF GLASGOW

TO INQUIRE INTO THE

METHODS OF DISPOSING OF SEWAGE

ADOPTED IN VARIOUS TOWNS IN ENGLAND.



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MINUTES OF APPOINTMENT OF DEPUTATION.

At Glasgow, *the 28th September*, 1876.

Convened—The Committee on Sewage.

It was remitted to the Sub-Committee appointed on 21st June
st (viz., Councillors Salmon, W. R. W. Smith, and Ure) to visit
eeds and Bradford, and any other towns they may consider advis-
ble, and examine the systems in operation for the disposal of
ewage and refuse, and to report. It was agreed to suggest to
ie Board of Police that they should appoint a Deputation to
ccompany the Sub-Committee.

At Glasgow, *the 6th October*, 1876.

Convened—The Sub-Committee on Sewage appointed on 21st June last. Present also, Bailie Burt, a Member of a Sub-Committee appointed by the Board of Police.

The Sub-Committee, as authorized by the Committee on 28th
lt., resolved to proceed to England on the 18th inst. for the
urpose of examining the systems in operation for the disposal of
ewage and refuse in Leeds, Bradford, and any other towns they
ay find it to be desirable to visit. The Sub-Committee resolved
o ask Dr. Wallace and Mr. Whyte to accompany them.

BOARD OF POLICE, *2nd October*, 1876.

As suggested in a letter from the Lord Provost, the Board appointed Bailies Burt and Ure a Sub-Committee to visit some towns in England, along with Members of the Sewage Committee of Council, and make inquiries with the view of ascertaining the best means of disposing of sewage.

16th October, 1876.

On the Motion of Bailie Ure, the Board added Dr. Russell, Medical Officer, and Mr. John Young, Inspector of Cleansing, to the Sub-Committee appointed on 2nd October current, to visit several towns in England in reference to the disposal of sewage.

At GLASGOW, *the 15th day of January*, 1878.

Convened—A Special Meeting of the Magistrates and Council. The Hon. the LORD PROVOST in the Chair.

The Lord Provost stated that the present Meeting had been called for the purpose of considering the Report brought up by the Committee on Sewage at the Meeting of Council on 1st November last. The Council thereupon proceeded to consider the Report, when Councillor Salmon moved that the Report be approved of generally, and that the Town-Clerk be instructed to transmit it to the Magistrates and Council acting under the Police and Public Health Acts, with a request that they will consider and deal with it. Councillor Morrison seconded the Motion. After considerable discussion, the Motion was adopted.

REPORT BY THE DEPUTATION

APPOINTED BY THE

TOWN COUNCIL AND BOARD OF POLICE OF GLASGOW

TO INQUIRE INTO THE

METHODS OF DISPOSING OF SEWAGE

ADOPTED IN VARIOUS TOWNS IN ENGLAND.

In accordance with the remit to us, we have visited various towns in England, and have made most minute inquiries into the methods adopted for the disposal of Sewage in these places. A detailed account of the processes will be found in the Appendix to this Report. At all the towns visited we were received with the greatest attention by the various authorities, and every facility was afforded us in the prosecution of our inquiries. Our special thanks are due to the following gentlemen:—Mr. James Gascoigne Lynde, C.E., City Surveyor, and Dr. Leigh, Medical Officer of Health, Manchester; Mr. W. S. Till, Borough Engineer, and Dr. Alfred Hill, Birmingham; Mr. E. A. Purnell, City Surveyor, and Mr. J. F. Coddington, Manager of the Manure Works, Coventry; Mr. Alderman Wood, Mr. Morant, Borough Engineer, Dr. Goldie, Medical Officer of Health, and Mr. Newhouse, Inspector of Cleansing, Leeds; Mr. Allison, Borough Engineer,

Dr. Butterfield, Medical Officer of Health, and Mr. G. Alsing, Manager of the Sewage Works, Bradford; Mr. Edward R. S. Escott, Borough Surveyor, Halifax; Dr. Alfred Carpenter, Chairman of the Sewage and Farm Committee of the Local Board, and Mr. Wright, Croydon; and Mr. Henry J. Morgan, Manager of the Lodge Experimental Farm, Barking.

Conservancy of Rivers.

The question of the conservancy of the rivers on which the towns in the Midland Counties of England are situated was constantly pressed on our attention during our visits, and especially at Birmingham, Bradford, and Leeds, at which places the purified sewage is incomparably purer than the grossly polluted streams into which it flows. These and many other towns are subjected to the manifest injustice of being compelled, under heavy penalties, to render their sewage clear, inodorous, and almost perfectly colourless, before discharging it into rivers or streams which are often, as in the case of the Bradford Beck, literally common sewers of the foulest description. The inhabitants of these towns complain bitterly that in the upper reaches of the rivers wholesale pollution is permitted, while they have been put to great expense in order to accomplish a purification, the effects of which are swallowed up in the filth of other towns over which they have had no control. The necessity for a Conservancy Board to watch over the whole drainage area of the various river basins was constantly dwelt on by the various authorities as the only effectual means of solving the important questions which are so intimately connected—the disposal of sewage and the restoration of the rivers to a state of purity. In the immediate vicinity of the great pumping station for London sewage at Abbey Mills, the large and important district of Stratford, itself part of the Metropolis, is left wholly undrained, the Metropolitan Board of Works refusing o admit

Necessity for Conservancy Boards.

the sewage except at a price which the Local Board are not willing to pay. The fact being that the sewage question is, in London, only partially solved, the Board of Works do not know how soon they may be called upon to purify their sewage before passing it into the river; and, as this will enormously increase the present outlay, they are unwilling to undertake the carriage of additional drainage at a rate which may ultimately prove insufficient. The formation of a Conservancy Board appears to us to be the first step that should be taken in regard to the purification (or rather restoration to purity) of any river, and we are strongly impressed with the belief that until such a Board is constituted for the Clyde, in accordance with the recommendation of Sir John Hawkshaw, no sewage works can safely be undertaken. We may add that our action in regard to this matter is being closely watched by the municipal authorities in the great English towns.*

The Sewage Question only partially solved in London.

The formation of a Conservancy Board the first step in the purification of a river.

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* It may be advisable, in reference to the towns visited by the Deputation, to mention that, with the exception of London, their condition, as to the water-carriage and outfall of their sewage, is very different from that of our own city. Glasgow and certain other towns in the kingdom discharge their sewage into tidal rivers of such volume and fall as apparently to protect the health of both their urban and suburban populations. But Leeds, Manchester, Birmingham, Bradford, Coventry, and many other urban communities, are compelled, by their inland position, to drain into rivers of such small capacity that in most cases the sewage before long becomes the predominant portion of the streams, and so thoroughly poisonous as to endanger the health of the surrounding districts. These results leave no choice to the resident Authorities, who, in self-defence, and often in obedience to Imperial Mandate, are compelled to adopt various schemes to protect the health of their respective communities. It is this condition of things, this necessity, which has encouraged, or rather compelled, the numerous sewage inventions now afloat in the kingdom, and especially in the midland counties of England, where the land is so level, and the streams so comparatively small and sluggish. Hence the attempted conversion of sewage sludge into manures, cements, and ammoniacal salts, and the efforts to establish farms over which the sewage, which otherwise they know not what to do with, may be spread, with the hope of enticing nature to yield large productions. Our own circumstances, fortunately, are of a more favourable character.

Glasgow different from most of the English towns as regards facilities for disposal of sewage.

Objects of Deputation.

While an important object of the Deputation was to obtain information which might be useful to the Council in dealing with the purification of the river, we found it difficult to do this without at the same time giving due consideration to collateral and, in a sanitary point of view, even more important inquiries. It has never yet been shown that the foul condition of the Clyde is directly injurious to health, while it has been amply demonstrated that sewer gases are responsible for the propagation of disease of a most deadly character. We have, therefore, given special study to the disposal of these deleterious gases, without which any general scheme for the purification of the river and the improvement of the city would be incomplete.

The dry system and water-carriage.

There are two ways in which excremental matter may be dealt with—the dry system, and carriage by water. The first is the most rational, as well as the most consistent with public health and with national prosperity. The weak part of this system, however, is that, while it disposes of excreta, it leaves untouched all the other sewage, which would still require to be removed by water-carriage, and be purified, of course, before passing into a river in the same way as if it contained the whole excreta. While, therefore, we hold that, upon economical and sanitary grounds, water-closets, especially in houses of the smaller sort, and in public works, jails, railway stations, &c., should, as far as possible, be replaced by an efficient dry system, we do not think that the adoption of this course will very much lessen the amount of sewage to be dealt with, or render its purification less imperative.

Water-carriage methods of disposal.

When water-carriage is used, the following methods may be employed for the disposal of the sewage:—

1st. Running it into the sea, or into a tidal river, under conditions that will prevent its return.

2nd. Irrigation.
3rd. Intermittent filtration.
4th. Purification by precipitation—
(*a*)—by Lime.
(*b*)—by Sulphate of Alumina.
(*c*)—by the A B C system.

The dry method includes— Dry system methods.

1st. Pan closets.
2nd. Earth closets.
3rd. Goux system.
4th. Stanford's system (Carbon Fertilizer Co.).
5th. Liernur's Pneumatic system.

These various methods will be briefly considered in their relation to the requirements of our own City.

The system recommended by Messrs. Bateman & Bazalgette and Sir John Hawkshaw for the disposal of the Glasgow sewage is to pump it up to a high level, and to carry it down to the Ayrshire coast and then run it into the sea. The example of London in running the unpurified sewage into the Thames is scarcely one that can be followed by Glasgow. The average range of the tide in the Thames, at London Docks, is 18 feet, while in the Clyde, at Glasgow Harbour, it is only 9 feet 9 inches: the average velocity of the ebb-tide on the Thames, is $2\frac{3}{4}$ *miles* per hour, while on the Clyde it is only $2\frac{1}{4}$ *furlongs* or little more than one-tenth of the speed. When the sewage of London is run into the Thames at Barking and Crossness, during the first three hours of ebb-tide, it passes down the river so far, before the tide flows, that it cannot return. This would not be the case in the Clyde, with its small range of tide and sluggish current; and if, therefore, the sewage of Glasgow is to be introduced into the

Bateman & Bazalgette's and Sir John Hawkshaw's proposals.

Range of tides in the Thames and Clyde contrasted.

Clyde at a distance of some miles from the City, as referred to at page 11 of Sir John Hawkshaw's Report, it must first be purified either by irrigation or precipitation.

If the sewage of Glasgow were taken to Farland Point, or the Sands between Irvine and Saltcoats, the scheme would resemble that carried out by Sir J. Hawkshaw for the town of Brighton, the sewage of which is carried direct into the sea at a place called Portobello by a main outfall sewer, about 8 miles in length, with a fall of 3 feet per mile. Considerable difficulty was at first felt in regard to the escape of the gases generated in this sewer and pressed backward by the returning tide, but considerable amelioration was effected by trapping off the lower part of the sewer, and ventilating the upper portion by means of a shaft or chimney, 100 feet high, with a large fire below. Ventilators have also been made in the streets for the free escape of the gases, and the condition of the town is now fairly satisfactory. A good deal has been said of the offensiveness and danger to health caused by sewage run into sea water, in which the noxious matters decompose and are oxydized much more slowly than in fresh water, and there is no doubt that in cases where the sea is inclosed in a deep bay, and protected from tidal currents, the evil sometimes becomes very serious. Many examples of this might be cited regarding sea-coast towns in this country, and also on the continent, but probably a better illustration could not be adduced than the town of Campbeltown, the sanitary condition of which some time ago was very bad. In Liverpool, very efficient ventilation of the sewers is said to have been obtained by iron pipes placed against the warehouses, and provided at the top with archimedean screws, and in the private houses by means of the rain conductors. In addition to these, there are numerous openings in the streets,

Sir J. Hawkshaw's scheme for Brighton.

Gases pressed back by the rising tide.

Ventilation of main sewer by shaft or chimney.

Sewage in sea water.

Campbeltown.

Ventilation of sewers in Liverpool.

so that the gases pressed back by the tide are not forced, as they are in many coast towns, into the houses.

Irrigation purifies the sewage, and, to some extent, utilizes it.

The second method of dealing with sewage, is to use it in the irrigation of land, and this system has the double advantage of purifying the water in a more complete manner than can be attained by any process of chemical treatment, and of utilizing, to a certain extent, the manurial value that exists in it. Great hopes were, a few years ago, entertained that in irrigation had been found the grand solution of the sewage question, and companies obtained from various towns concessions of the sewage for a term of years, as if it were an article possessing a practical value. All that is changed now; sewage farms, on which immense sums of money have been expended, have been reluctantly abandoned, and irrigation is no longer regarded as anything more than a means of obtaining a good effluent at a moderate outlay. Probably the Beddington Manor Estate, at Croydon, is the most successful of the sewage farms, and it is no small matter to say, that it disposes of the sewage of a population of 60,000 persons, at an outlay which is now reduced to little over £1000 per annum. But the situation of Croydon adapts it in a peculiar degree to the utilization of its sewage by filtration through land. The quantity of water used in the town per head of population is much less than in Glasgow, and the rain-fall not much more than half; no pumping is required, and land is obtained in the immediate vicinity of the town. Again, the land, although not naturally of high quality, is exceedingly well adapted for sewage farming, in consequence of its being of a loose and permeable character, with a bottom of gravel, which acts as a natural drain, and prevents any accumulation of the sewage upon the surface of the ground under any circumstances. During the visit of the

Many sewage farms have been abandoned.

Croydon one of the most successful sewage farms.

Croydon well adapted by its situation for disposal of sewage by irrigation.

Opinions regarding sewage farms.

Deputation to this and other sewage farms, the weather was comparatively cold, and this may account for the fact that no odours of a truly offensive nature were observed; but if we can accept the testimony of others, this satisfactory state of matters does not appear, at all times, to exist. Mr. Thomas Hawksley, C.E., gave the following evidence before a Committee of the House of Commons in 1870 (Blackburn Corporation Inprovement Bill):—"Water irrigation carried on in warm weather is exceedingly unhealthy; in fact, you make, so to speak, a kind of fen of the large area of land you put the water over." . . . "Where the water is foul [that is, not purified by precipitation] I can speak positively to it, from repeated observation in different places, that the odour, particularly at night, and particularly upon still damp evenings in autumn, is very sickly indeed, and that in all these cases a great deal of disease prevails." . . . "With regard to sewage irrigation, this happens:—The sewage forms a deposit on the surface of the ground; that deposit forms a cake of organic matter, and that organic matter, when it is in a damp state, as it usually is, gives off in warm weather a most odious stench."

Mr. T. Hawksley, C.E.

Dr. Letheby.

The late Dr. Letheby, Medical Officer of Health to the City of London, also gave powerful evidence against sewage farming as affecting the health of a district. It is right to add, that at Edinburgh, Croydon, and several other places no evil effects have been traced to the influence of the farms irrigated by their sewage, and that many of the most reliable medical authorities, both in this country and on the continent, confidently affirm that sewage farming is not attended with injurious effects upon health.

Mr. Crookes.

Mr. Crookes, F.R.S., a distinguished chemist, makes the following observations on sewage farming:—"The finest

manurial qualities are possessed by the constituents of sewage, but the irrigationist is so wasteful in their application that, in the majority of cases, there ensues not a healthy crop, but a mass of overgrown rank grass material of no more nutritive value than weeds; for it must be distinctly remembered that this is not a question of manuring with sewage when necessary, but the compulsory application of enormous quantities, in season and out of season, till the surfeited land is sick; and even then it has to take more still."

Quantity of land required for irrigation.

The quantity of land that appears to be necessary, under favourable circumstances, as at Croydon, is about an acre to each 100 of population, so that Glasgow, with its immediate suburbs, would require, at the present time, fully 10 square miles of land—an extent of surface which would require constant additions in order to keep pace with the increasing population. The greater part of the sewage would require to be pumped to a considerable height, the land (supposing it were possible to obtain it) would require to be held by the Corporation; and, as experience has shown in the case of the Lodge farm at Barking, large quantities of certain crops would be obtained which it would be impossible to dispose of to advantage. Again, it is quite certain that the land so used could never become residential, or be occupied otherwise than by the labourers engaged on the farm. This is even the case at Croydon; although, as already mentioned, the circumstances are there peculiarly favourable to sewage farming.

A sewage farm increases the supply of food, and gives increased employment to the labouring population.

There is one aspect of the irrigation question which we think it right to present, viz.—that on a skilfully conducted sewage farm, as contrasted with an ordinary agricultural farm, the cost of labour amounts to three or four times

the sum usually expended, per acre, while the produce is, at the same time, greatly augmented. The question arises whether, if it costs a town, say, £10,000 per annum to purify its sewage by chemical treatment, and then to run it into a river or into the sea, and a like sum is lost in the working of an irrigation farm, is there not the manifest advantage gained to the country by a large expenditure in the wages of labour, and the greatly increased supply of food for man and beast? Given, therefore, a sufficient quantity of land at a reasonable distance from the town, and free from a resident population; and looking to the superior effluent produced, irrigation presents the most perfect means for the disposal and purification of sewage: and it is consistent with the facts presented to us at various places that, if the levels of the land were suitable for the reception and distribution of the sewage without pumping, and if the land were obtainable at an ordinary agricultural value, a sewage farm might be made to yield a profit.*

Circumstances under which irrigation is the most perfect means of disposing of sewage.

Purification by chemical treatment has been much misunderstood, and consequently discredited. Because it has not done all that has been claimed for it, some have been inclined to regard it as a failure, and unworthy of consideration. Several processes have been advocated for purifying sewage by precipitation, and at the same time manufacturing from the sludge obtained a manure which will be saleable at a considerable price, under the name of native guano, or some other high-sounding title. The purification of the sewage is possible, and has been carried out successfully at Bradford, Leeds, Coventry, Birmingham, and other towns; but so far as we

Chemical treatment.

* This view of the question of irrigation by sewage was very clearly presented to us by Mr. Henry J. Morgan, Manager of the Lodge Farm, Barking, as the experience derived from that valuable but costly experiment.

have been able to ascertain, the sale of the so-called manure, except in insignificant quantities, appears to have failed of accomplishment. And this is not to be wondered at; for the precipitant, whatever it may be, while it removes the solid matter of the sewage, together with the phosphoric acid, leaves in the effluent water all, or nearly all, the ammonia and all the potash salts, these constituting by far the most valuable part of the sewage. All hope of making anything of the precipitate or sludge should, therefore, be abandoned; but that is no reason why the process should not be adopted for the purification of sewage.

Matters removed by lime and by alumina.

The matters removed by lime and by alumina, which are practically the only precipitants that have hitherto been employed, are—

Solid matters,
Phosphoric acid,
Fatty acids of soap,
Nitrogenous organic matters,
Vegetable colouring matters,
Magnesia.

Soluble nitrogenous compounds soon become oxydized.

The nitrogenous compounds and the ammonia in the effluent soon become oxydized, less rapidly in salt than in fresh water; and the oxydation is greatly facilitated by passing the purified sewage, as at Bradford, through a porous material, with free exposure to the air.

Lime the precipitant most capable of general application.

Of all the substances proposed for precipitation, the one that appears to be most capable of general application is lime. It can be had everywhere, is cheap, and effects a sufficient purification to enable the effluent to be passed into a non-potable running stream or tidal river, especially if the precipitation is supplemented by filtration through some form of charcoal, or by running it over a limited extent of

The lime effluent soon decomposes and readily oxydizes.

suitable land thoroughly drained, as at Coventry. It has been objected to the lime process that the effluent soon decomposes, while that from other precipitants, being neutral or faintly acid, resists putrefaction for a much longer time. This is quite true, but it appears to us that the fact that the lime effluent readily oxydizes is entirely in its favour. The organic matter in the purified sewage *must* be oxydized, and the sooner this is accomplished the less likely is it to produce injurious consequences.

The sludge should not be allowed to remain long in the settling tanks.

Under any system of precipitation, it is most important that the sludge should not remain long in the bottom of the settling tanks; whenever it is permitted to accumulate for a week or two it ferments, throws up bubbles of the gaseous products of decomposition, and serves to render the effluent offensive.

Sulphate of alumina.

Precipitation by a solution of sulphate of alumina mixed with the sewage, and afterwards neutralized by lime, is used at Coventry, and probably other towns. The special advantage gained by this process (Dr. Anderson's) is, that the bulk of the sludge is sensibly less than that obtained by lime.

A B C process.

The A B C process, as it is called, has become notorious, not so much, probably, from its inherent merits, as from the pertinacity with which its claims have been advocated by the proprietors of the patent, or rather series of patents. Indeed, so much has been affirmed regarding its capabilities that the Rivers Pollution Commissioners made it the subject of a special series of investigations, and published a Blue-book concerning it in 1870. It will be sufficient to quote the "Conclusions," page 18:—

Report of Rivers Pollution Commissioners on it.

"Our investigations into Sillars' or the A B C process of treating sewage, as carried out at Leicester and at Leamington, extending over nearly two years, have led us to the following conclusions:—

"1. The process removes a large proportion of the *suspended* impurities from sewage, but on no occasion, when we have seen it in operation, has this removal been so complete as to render the effluent sewage admissible into running water.

"2. The A B C process removes a very small proportion of the soluble polluting matters from sewage. After treatment by this process, the effluent sewage is very little better than that which is obtained by allowing raw sewage to settle in subsidence tanks.

"3. The manure obtained by this process has a very low market value, and cannot repay the cost of manufacture.

"4. The manipulations required for the extraction and drying of this manure are attended with a nauseous odour, especially in warm weather, and would occasion a serious nuisance if the works were situated in or near a town."

Origin of the name—no longer applicable.

The name of the process has been taken from the initial letters of the three substances considered essential to the process—alum, blood, and clay, but other substances have been used, and the mixture of substances has suffered a great variety of changes. The following is stated in the final specification, as proportions which have answered well for ordinary sewage:—

Mixture given in specification.

Alum, ...	600 parts.
Blood, ...	1 ,,
Clay, ...	1,900 ,,
Magnesia, ...	5 ,,
Manganate of Potash, ...	10 ,,
Burnt Clay, ...	25 ,,
Common Salt, ...	10 ,,
Animal Charcoal, ...	15 ,,
Vegetable Charcoal, ...	20 ,,
Magnesian Limestone, ...	2 ,,

Quantity used.

The quantity required is stated to be about 4 lbs. per 1000 gallons of sewage, equal to about $1\frac{3}{4}$ tons per million gallons. In singular contrast to the above are the proportions most

recently employed at Leeds, as described in the Appendix to this Report, viz.:—

Materials used at Leeds.

Alum, or Sulphate of Alumina,	...			...	3 parts.
Charcoal of some kind, ...	...	...		...	3 „
Clay, ...	...	...	...	...	6 „
Lime, ...	...	...	...	...	12 „

In this mixture the essential ingredients appear to be alum and lime, the latter being used in considerable excess, as appears from the composition of the dried sludge (*vide* Appendix, page 29). As regards clay, it is a fact that the sewage of some towns contains already too much of that substance; and what is added only increases the bulk and weight of the sludge, without offering any compensating advantage. One object of the addition of clay is to ensure rapid precipitation; but this appears to be equally well attained by the use of lime alone (*vide* Appendix—Bradford).

Clay does not appear to be necessary or advantageous.

The disposal of the sludge an important element in the cost methods suggested.

If a system of precipitation be adopted for Glasgow, the disposal of the sludge will be one of the most important elements in the calculation of cost. Probably it might be used to some extent for filling up waste and low-lying land on the banks of the river; but, if not required for this purpose, it might be carried seaward, and deposited in the same way as the dredgings of the river are disposed of at the present time.

Intermittent filtration.

We have not referred to intermittent filtration as a means of purifying sewage. It has been carried out quite successfully at Merthyr-Tydvil; but the conditions are there so exceptional, that there are very few places where the process could be pursued with equally satisfactory results. It appears to be in operation also at Kendal.

Defects of water-carriage system.

Before leaving the subject of water-carriage we must refer, however briefly, to the defects of the system. We are well aware that the purification of the river, however desirable on

æsthetic grounds, would do little or nothing for the diminution of our death-rate, or the salubrity of our homes. It will not prevent the formation of sewer gases, or the passage of these pestilential effluviæ into our dwellings; on the contrary, unless special precautions are taken there will be, from the connection of the sewers with the intercepting main drains, accompanied in some instances by a diminished rate of flow of the sewage, the inevitable result of decomposition and evolution of sewer gases in greater volume. This is not without illustration in towns which have adopted a system of intercepting sewers, and especially when pumping has been necessary. We direct attention to this risk, because if a scheme of purification be carried out, either by conveying the sewage direct to the sea, or by defecating it and then returning it to the river, it will become more than ever necessary that a systematic and careful consideration be given to the general ventilation of each section of the common sewers of the City, from their outlets to their primary branches. Likewise, as regards the private portion of the drainage system of the City—that between the common sewer and the house, and thence up through the building—that also should, in each case, be carefully ventilated on some well-devised plan, quite independently of the common sewer. The structural details by which this may be done, afford ample scope for discussion and selection, but for all circumstances suitable means have been carefully described, and in many localities enacted.*

The purification of the Clyde will not sensibly diminish the death-rate in Glasgow, nor prevent the formation of sewer gases.

Ventilation of drains and sewers will be, more than ever, necessary.

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* As examples for our guidance, we may mention "Model Bye-laws issued by the Local Government Board, for the use of Sanitary Authorities, IV., New Streets and Buildings," Sections 60 to 66; and also, "Bye-laws and Regulations with reference to House Drainage, adopted by the Uppingham Sanitary Authority," referred to in the report of the Society of Arts' Second Annual Conference on the Health and Sewage of Towns, page 65.

Examples for our guidance as regards ventilation of sewers.

Use of water-closets discouraged in small houses.

It has been suggested that the use of water-closets should be discouraged as much as possible, especially in houses of the smaller class, where they are more likely to get out of order and to prove injurious to health than in houses of the better description.

Stables and byres.

Drainage from stables and byres should be absolutely prohibited. All the flooring of these should be water-tight, and the liquid matters should be absorbed by sawdust or other suitable material.

Chemical and other factories.

As regards chemical and other factories, from which enormous quantities of refuse matters are emitted, manufacturers should be prohibited from putting into the sewers any liquid having an acid reaction, as such liquids (pot-ale from distilleries, for example) decompose certain compounds in the sewage and liberate noxious gases. As lime is cheap, there will be no hardship in carrying out this regulation. All solid matters of whatever kind should also be kept out of the sewers.

Dry systems.

We now come to the consideration of the various dry systems of disposing of that portion of the sewage of towns which is due to excrementitious matters.

Glasgow not wholly a water-carriage city.

Although Glasgow may be correctly described as a water-carriage city, it must not be overlooked that a very large proportion of the inhabitants are not provided with water-closets. In the statistics given in the Appendix, it will be observed that, while the number of dwelling-houses in Glasgow is upwards of 100,000, the water-closets number only 32,000, showing that less than one-half of the population is supplied with these conveniences, while the remainder are provided with one form or another of dry-closet. The study of this branch of the inquiry has, therefore, naturally occupied much of our attention.

In most of the towns which we visited the system of dry collection and removal is being considered in consistent relation to the system of sewage disposal. Obviously, in the management of both the principle to be steadily worked out, is the rapid removal of the noxious material from the vicinity of the habitations of the people. In Leeds the old-fashioned privies are being replaced by trough water-closets, so that there the fulfilment of this end is being more and more entrusted to the common sewers. In Manchester and Birmingham, on the other hand, water-closets are systematically discouraged and repressed, and elaborate attention is being paid to the development of dry collection and daily removal of the material. We look to these latter cities as the examples for our guidance. We strongly commend, on sanitary grounds, the tub and pail system.* There can be no doubt in the mind of any one who brings his senses of smell and sight to decide as between our most improved ashpits or ashpits and privies combined, emptied with great trouble and much nuisance at long intervals, and the separate tubs for ashes and pails for excreta emptied daily with comparatively no nuisance, and replaced clean, as in the English towns referred to in the Appendix. The gain in health and decency is great and unquestionable.

Trough water-closets in Leeds.

Manchester and Birmingham—Water-closets repressed and dry system extended.

The "tub and pail" system recommended on sanitary grounds.

The Goux system consists in collecting the excreta in a pan or pail lined with a mixture of an absorbent nature, and it has been carried out in various English towns, particularly at

Goux system.

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* The gradual introduction of this system during the last few months into Glasgow was, as the result of the observations of this Deputation, resolved upon by the Board of Police before its duties were transferred to the Magistrates and Council by the recent Act of Parliament.

Halifax (Appendix, page 34), which was visited by the Deputation for the special purpose of inquiring into the merits of the system. Although it appears to be satisfactory in a sanitary point of view, it is less simple, and apparently not more advantageous than the pail or pan system already referred to.

Earth-closet.

The earth-closet is an excellent adaptation of a universal natural law, the returning of excreta to the soil, which at once acts as absorbent and deodorizer, and the charcoal-closet is still better, in so far that the weight of charcoal is small as compared with that of the quantity of earth required to effect a similar amount of absorption and deodorization. But these closets, although admirably suited for country houses of the better class, are too costly to work to be used for ordinary workmen's houses in a crowded city. The charcoal system has been introduced on the large scale at Oldham by the Carbon Fertilizer Co., but the way in which the work is carried on did not appear to the Deputation to be at all satisfactory.

Charcoal system.

Liernur's pneumatic system.

No report on sewage would at the present day be complete without a reference to the pneumatic system of Captain Liernur. A detailed description would occupy too much space in this Report, but an excellent popular account of it has recently been published by the Rev. Dr. Esdaile of Dundee (*Good Words* for November, 1876). Details of the system, as carried out at Dordrecht, Leyden, Amsterdam, Vienna, and other continental towns and cities, will be found in the Report on the Conference on the Health and Sewage of Towns, held at the Society of Arts, London, May, 1876. The Deputation deeply regret that the limited time at their disposal prevented them from visiting Holland, for the purpose of witnessing the working of the system, which has not,

as yet, been adopted by any town in this country. The distinctive feature of the process is that the night-soil, with or without a limited quantity of water, is drawn by means of a vacuum to a central depôt, where it is evaporated to dryness in vacuo, forming a "poudrette," which possesses a high manurial value, and may truthfully be called native guano, a name which has been applied by the A B C Company to the same article—*minus* its ammonia and alkaline salts and *plus* a large quantity of clay and other useless material. While the pneumatic method of disposing of the excreta is the central idea of the system, it includes also distinct operations for dealing with kitchen-sink refuse and street washings. A letter on the subject, by Captain Liernur, appeared in the *Glasgow News* of 11th December, 1876. We cannot express an opinion upon the working merits of the system, but we may say that, theoretically, and in an economic point of view, it appears to be perfect, since the whole of the excreta is converted into a highly portable and valuable manure, while all risk of sewer gases being formed is entirely obviated, and all the operations, being conducted in vacuo, are entirely free from offence.

Report on Liernur's system by Messrs. Rawlinson and Read.

The following remarks on the pneumatic system are quoted from the Report to the Local Government Board by Messrs. Rawlinson and C. S. Read, dated 21st July, 1876:—"Captain Liernur has been particularly fortunate in having the manure which his system produces tried in Holland, as the use, application, and storage of liquid manure is much better understood there than in England. A considerable number of the farmers in Holland grow no straw, consequently the manure made by the cattle in winter has to be utilized in a liquid state. In England this liquid manure is generally absorbed by the straw, or by other bedding upon which the cattle stand.

Some twenty years ago there was a general movement amongst English farmers for applying the drainage from farm yards to the land, and tanks, pumps, and liquid manure carts were, for a time, in great request; but the application of this farm sewage produced so little result in proportion to the cost, that pumps and carts for this purpose are now seldom used upon arable farms. We are confident that the liquid which is collected at such cost in barrels would find no ready sale in England, even at a very low price, and we further believe that any English farmer agreeing to take it continuously would not only not pay anything for it, but would certainly charge something considerable for his trouble and for the expense of removal.

Conditions under which the pneumatic system may be applicable.

"If the towns of Holland, or portions of such towns, by reason of peculiarities of site and climate, cannot be sewered on English principles, and if the pneumatic system is as cheap as any of the moveable pail systems, it may be best under such conditions for Holland, because, if worked in accordance with the rules laid down, the excreta will be removed daily without the intervention, trouble, and dirt involved in the pail system. The pneumatic system only deals, however, with a small fraction of the refuse to be removed from houses, leaving all other forms of refuse to be dealt with in the ordinary way, so that Dutch town sewage must flow into the rivers and canals as now, to pollute the water supply; or some complicated mode of intercepting it must be provided at an additional cost to the local authorities.

Not suitable for English towns.

"The pneumatic system is ingenious, but it is complicated in its construction and working arrangements; and, consequently, it is liable to derangements which are sometimes difficult to mend. We do not know one English town in which the apparatus, if adopted, would be other than a costly toy.

"As may be imagined, when the nature of the arrangements and complications are considered, the pneumatic system gets out of order, the slightest crack in any pipe or pipe-joint will reduce the force of the partial vacuum, and even when all the apparatus remains sound, the closet pans may not be emptied; and, in fact, neither the pipes nor the pans ever are entirely emptied. The power of air and water to remove solids through pipes is proportional to their relative weight and velocity, and air is to water, by weight, about as 800 to 1." *

RECOMMENDATIONS.

Recommendations.

1. That the system of having water-closets for public works, factories, jails, workhouses, infirmaries, and railway stations, should be forbidden, so as to reduce the quantity of water-closet sewage now turned into the river. Water-closets in small houses should also be discouraged.

2. That the ordinary privies and ashpits be altered to the tub and pail system, to be cleansed daily, as it has been carried out in Manchester and other important English cities and towns; and that special accommodation be provided for children.

* It may be well to mention that the Convener of the Committee obtained a plan and estimate from Captain Liernur about two years ago for applying his system of drainage to a section of Hutchesontown, near Hutcheson Square, containing a population of about 10,000. This plan is an illustration of the skill with which the patentee makes provision for every emergency likely to arise in working the Pneumatic principle in such cities as Glasgow. The plan will, of course, be forthcoming should circumstances arise to lead the Town Council to a consideration of the proposal.

Recommendations continued.

3. That all drains, soil and waste pipes, and all apparatus connected with water-closets, sinks, and baths, and their connections, be executed under public supervision.

4. That a complete system of ventilation of the common sewers throughout their entire length be immediately adopted.

5. That a system of ventilation of the house drains and soil-pipes, independent of that of the common sewers, be immediately adopted and enforced throughout the city.

6. That the use, for dietetic purposes, of water from cisterns supplying water-closets should be absolutely forbidden.

In the event of it being found necessary to purify the River;

7. That the whole drainage of the city be taken into main intercepting sewers, and conducted to a suitable point, and after being rendered clear by precipitation and filtration, passed into the Clyde.

8. That the sludge obtained in the precipitation process be got rid of in the cheapest possible manner. A part of it might be utilized in making up waste land, and a certain quantity might be taken away by farmers; but the greater part would probably require to be disposed of in the same manner as the dredgings of the river.

Utilization of the sewage abandoned.

It will thus be seen that we entirely discard the idea of utilization of the sewage itself, or the precipitate obtained by the action of lime or other chemical agents. The sludge obtained by any of the patented processes is dried at such cost, and its value when dry is so trifling, that all hopes of

disposing of it for manurial purposes—at a price that would be remunerative—are entirely illusory.

Purification of the river less important than other recommendations.

In conclusion, we have to remark that, while we consider the purification of the Clyde an important and necessary work, we are of opinion that, for the health of the city the recommendations we have made upon the other details of the sewage question are of much greater consequence, and we trust that these will be carried out without unnecessary delay.

(Signed) JAMES SALMON.
WILLIAM R. W. SMITH.
JOHN URE.
JOHN BURT.
WILLIAM URE.

WILLIAM WALLACE.
JAMES B. RUSSELL.
JOHN WHYTE.
JOHN YOUNG.

GLASGOW, *October*, 1877.

APPENDIX.

DESCRIPTION

OF

THE SEWAGE ARRANGEMENTS

OF

THE TOWNS VISITED BY THE DEPUTATION,

18TH-28TH OCTOBER, 1876.

I. LEEDS.—The population of this town is 291,580, and it covers an area of 21,572 acres, of which, however, a large portion is unbuilt upon. The town at present sewered covers an area of about 4900 acres, with a population of 245,000, thus showing a population of 50 to the acre, while Glasgow has 88·6. The average mortality for the five years, 1871-1875 inclusive, is 27·4 per 1000. A considerable portion of the town is not sewered, and only about four-fifths of the drainage is connected with the sewage works. The total length of the sewers in the town is 130 miles. The water supply is taken partly from the River Wharfe and partly from the Wash Burn, and the quantity used daily per head of population is 30 gallons—the quantity used in Glasgow being 53 gallons.* The hardness is 4½ degrees, and it contains 8·8 grains per gallon of total solid matter. It is bright and perfectly colourless, and appears to be of good quality. The average rainfall is 23 inches per annum. Leeds.

* This quantity has now been reduced to 46½ gallons.

Leeds continued. The number of water-closets in Leeds is 8500, and of ashpits and privies 13,100; about 3000 of the latter are provided with pails or boxes. Many of the privies have recently been altered into trough water-closets, which are highly approved of by Dr. Goldie, the medical officer of health. These trough closets are cleaned out periodically, by pulling up a plug and flushing the contents into the sewers. The existing system of drainage was commenced in 1850, and has been carried out at a cost of £280,000. The whole drainage is collected into a culvert at the lowest part of the town and carried to Knostrop, 2¼ miles from the Town Hall, where it is chemically treated and passed into the River Aire. It is worthy of remark that although the sewage works are quite outside the town, they are within the municipal boundary. Originally, experimental works were erected to test the efficacy of the A B C process, which was in the hands of the Native Guano Company. These works cost about £10,000, and were constructed to treat two million gallons of sewage daily. The success of the experiment, so far as producing an apparently good effluent is concerned, and the hope of being able to dispose of the dried sludge at a large profit, induced the Corporation of Leeds to erect works for the chemical treatment of the entire sewage of the town, amounting to from twelve to fourteen million gallons daily, and these works cost about £50,000, which, however, includes the price of 25 acres of ground, about 6 of which are occupied by the works. These consist of engine and mixing rooms, a series of 12 large tanks* for precipitation, sludge tanks and pond, settling pond, having an area of 5 acres, through which the purified sewage passes on its way to the river, and a series of drying cylinders for desiccating the sludge: 48 men are engaged at the works.

A B C process. The sewage is raised 18 feet by means of centrifugal pumps, and in the A B C process is mixed with crude alum, carbonaceous matter, and clay, together with lime. The proportions most recently used were, for a day's work—

Alum, ...	3 Tons.
Carbonaceous Matter, ...	3 ,,
Clay, ...	6 ,,
Lime, ...	12 ,,

making in all 24 tons of solid material. The quantity of *dried* sludge is about 27 tons. The cost, for materials alone, is 18s. 3d. per hour, equal to 18s. 3d. per ton of mixture, and the cost of drying the sludge down to 25 per cent. of moisture is 7s. per ton for coals,

* These Tanks measure, at the top, 100 feet by 60 feet; they have sloping sides, and the average depth is 6 feet. The total contents are 2½ million gallons.

power, and labour. The following is an analysis of the dried sludge by Dr. Wallace:—

A B C Sludge, Leeds. A B C sludge.

Water, ...	9·56
Organic Matter, ...	20·82
Phosphate of Lime, ...	1·39
Sulphate of Lime, ...	3·65
Carbonate of Lime, ...	13·27
Carbonate of Magnesia, ...	4·93
Magnesia, ...	3·29
Oxide of Iron, ...	4·61
Alumina, ...	7·04
Sand and undecomposed Clay, ...	31·60
	100·16
Nitrogen, ...	·66
Equal to Ammonia, ...	·80

The value of this dried sludge is calculated by Dr. Wallace to be 14s. 2d. per ton, but many excellent authorities value the A B C sludge (some of which is richer in nitrogen than that made at Leeds) at a much higher figure. Practically, however, it has been found impossible to dispose of it in any quantity, only 150 tons, or about six day's produce, having been sold during the present year, some of which was said to be enriched by the addition of night-soil and other town refuse. The valuation of a manure of this kind by figures applicable to guano and rich artificial manures, worth from £6 to £12 per ton, is altogether misleading; for the carriage of a vast quantity of material, such as would be required to manure a field with dried sludge, and the expense of spreading it on the ground, reduces its value to probably little, if at all, more than that of stable manure. Manurial value.

As regards the undried sludge, the farmers in the vicinity of the works refuse to accept it as a gift. It was stated to the Deputation that the whole of next year's produce of dried sludge had been contracted for at 12s. per ton.

The works, during the visit of the Deputation, were not in operation, owing to a break-down in the boiler-house, but they were to be started afresh in a short time on Hanson's process, which consists of treatment by lime and soda or black ash waste; 20 tons of lime and 4 tons of waste being used daily, at a cost, for materials alone, of 14s. 3d. per hour, producing, it is said, a good effluent, and 60 tons of wet sludge of no value. Mr. Hanson states that he is willing to undertake the purification of the Leeds sewage for £11,000 per annum by this process, while the cost under the A B C system has been, for about eight months of this year, £15,000, or at the rate of £22,500 per annum. If Hanson's process is finally adopted all hope of disposing of the sludge must be abandoned. Hanson's process. Cost of A B C and Hanson's processes.

Samples of the effluent and sludge from Hanson's process were forwarded to Glasgow and analysed by Dr. Wallace, with the following results:—

Effluent from Hanson's process.

EFFLUENT OF HANSON'S PROCESS, LEEDS.

	Grains per Gallon.
Carbonate of Lime, ...	2·10
Carbonate of Magnesia, ...	·52
Sulphate of Lime, ...	13·14
Sulphate of Magnesia, ...	4·53
Sulphate of Potash, ...	3·50
Sulphate of Soda, ...	4·47
Chloride of Sodium, ...	9·76
Alumina, &e., ...	·56
Siliea, ...	·42
Organie and Volatile Matters, ...	7·00
Total Solids, ...	46·00
Suspended Matter, ...	·45
Ammonia, free or Saline, ...	1·40
Do., Organic or "Albuminoid,"	·175
Phosphorie Aeid, ...	none
Oxygen required to Oxydize Organic Matter, ...	·48
Colour eompared with Loeh Katrino Water = 10,	20

Sludge from Hanson's process.

SLUDGE FROM HANSON'S PROCESS, LEEDS.

	Moist, as Received.	Dried at 212° F.
Water, at 212° Fah., ...	58·20	—
Organie Matter and Combined Water,	13·96	33·40
Phosphate of Lime, ...	·82	1·96
Sulphate of Lime, ...	·87	2·09
Carbonate of Lime, ...	14·20	33·98
Carbonate of Magnesia, ...	·58	1·39
Magnesia, ...	3·56	8·52
Oxide of Iron, ...	1·16	2·77
Alumina, ...	3·15	7·53
Siliea, ...	3·68	8·80
	100·18	100·44
Nitrogen, ...	·35	·83
Equal to Ammonia, ...	·42	1·01
Caleulated Values per Ton, ...	8s. 7d.	£1 0 7

The value of the Sludge with 10 per eent. of Water would be 18s. 6d. per ton.

Alderman Tatham on Leeds sewage.

Alderman Tatham, in his paper on the Leeds Sewage, read at the Conference at the Soeiety of Arts, London, in May last, summarizes as follows:—"There is no diffieulty in purifying sewage by precipitation, so as to render it admissible into a running stream, especially one like the River Aire, below Leeds, without causing a nuisance, or being injurious to public health, but this is done at a cost Whether or not this cost can be covered, or a

profit made by the sale of the residuum, remains to be seen. The best prospect we have of such return is from the A B C process. We have at present to choose between this and Hanson's; if his residuum is of equal value with the native guano, and will sell as readily, his would have the advantage; or if the Native Guano Company can reduce the cost of their ingredients and working to that of Hanson's, they will have the preference, unless Hanson's residuum sells as well as that of the native guano; but if both can be reduced to the same cost, and have the same return for residuum, then the preference will be for that producing the best effluent, and if these be alike, the two processes will be of equal merit." Leeds continued.

The sewage of Leeds is very dark coloured and dirty looking, and evidently contains a large quantity of spent dyeing materials. The following analysis of the Leeds effluent, from the A B C process, was made in 1875 by the late Dr. Letheby:— Effluent from A B C process.

In Solution—			
Mineral Matter, ...	54·54	grains per	Gallon.
Organic Matter, ...	4·59	,,	,,
Total Solid, ...	59·13	,,	,,
Chloride of Sodium,	11·79	,,	,,
Ammonia, Free, ...	1·20	,,	,,
Do., "Albuminoid,"	·14	,,	,,
Organic Carbon (estimated)	·92	,,	,,
In Suspension—			
Mineral Matter, ...	·22	,,	,,
Organic Matter, ...	·32	,,	,,
Total, ...	·54	,,	,,

As regards the cleansing of the town, the removal of the ashes and night-soil is contracted for, but the Corporation does the scavenging, and hires horses for sweeping the streets (by machines) and removing the sweepings. The sewers are ventilated by openings at the gutters, which are decidedly objectionable, and would be better in the middle of the streets. Ventilation of sewers.

II. Bradford.—The town of Bradford has a population of 173,000, and covers an area of 7221 acres, giving a density of population of 24 to the acre. The average death-rate is 26·1 per 1000. The number of water-closets is about 2000, and of dry closets, 3000. The works for the purification of the sewage, which contains much dye refuse, are at Manningham, about 1¼ miles from the town, and the levels are such that no pumping whatever is required. The sewage amounts, on an average, to from eight to nine million gallons per day, and the precipitant used is lime. The quantity of sewage, as well as its nature, is very irregular. During some hours of the day it runs at the rate of twelve million gallons per day, and in consequence of the washings from the dye-works, wool mills, and factories, requires from 16 cwt. to 1 ton of Bradford.

Bradford continued.

lime per million gallons; while at other times, when nothing but sewage strictly so called comes into the works, 10 cwts. of lime per million gallons are sufficient. The price of lime at the Bradford works is 13s. per ton. The lime is finely ground by means of a "disintegrator." In close proximity to this machine are the mixing boxes. These are simply big square vats of wood, in which work oscillating frames, also of wood. A small quantity of sewage is introduced into these vats and mixed with the pulverized lime—thorough incorporation being insured by the action of the oscillating frames, which keep the mixture in constant agitation. The "milk of lime" thus obtained is passed out through the walls of the building by an iron pipe and brought in contact with the sewage, so that both fall simultaneously into a canal leading to a series of 34 precipitation tanks, each measuring 28 by 23 feet, and having an average depth of 5 feet, the floors sloping away from the building. The capacity of each tank is 18,000 gallons. The sewage, after being impregnated with the precipitant, is allowed to flow into one of these tanks until it is filled—the filling occupying about two minutes; and the contents are allowed to stand at rest for half-an-hour or 40 minutes, by which time the lime has carried down with it to the bottom of the tank all the solid matter in suspension, the sludge at the bottom occupying not more than 5 inches. The clear water is then slowly drawn off by an ingenious arrangement (the invention of Mr. G. Alsing, the engineer of the works) which takes the water only from the surface. In a line with each precipitating tank is a filtering tank, 12 by 23 feet, and about 3 feet deep, and filled to the extent of 1 foot 6 inches to 2 feet with "breeze," or riddlings of gas-work coke, which acts as an excellent filter, the water passing almost quite clear and bright, although distinctly coloured by dyeing materials, the last traces of which appear to be difficult of removal. In front of the filtering tanks is a canal, also partially filled with "breeze," and beyond that again another canal which extends the whole length of the works (about 700 feet), and discharges the purified sewage by two openings into the Bradford Beck, a tributary of the Aire, and one of the most foully polluted streams in Great Britain.

Lime of finest quality, and ground.

The engineer (Mr. Alsing) considers it most important that the lime should be of the best quality, and ground to the finest possible powder. The quantity employed is about 18 cwt. per million gallons of sewage. The works have been in full operation for a year. They cost £65,000, but a large proportion of this was spent in experimental apparatus, and it is estimated that the

Cost of works.

works, *as they now stand*, could be erected for half this sum. The cost of working is £5000 per annum (not including the interest on the cost of the works); fourteen men are engaged, and an engine of fourteen horse power does all the grinding, agitation, and pumping that are required.

Samples of the sewage and effluent have been analysed by Dr.

Wallace, who has obtained the following results, represented in grains per gallon :—

BRADFORD SEWAGE. Bradford sewage.

DISSOLVED MATTERS—		
Carbonate of Lime, ...	3·64	
Carbonate of Magnesia, ...	2·94	
Phosphate of Lime, ...	17·22	
Sulphate of Lime, ...	6·02	
Lime, ...	69·16	
Magnesia, ...	8·40	
Chlorides of Sodium and Potassium,	11·55	
Oxide of Iron, ...	1·05	
Alumina,...	33·04	
Silica, ...	4·20	
Organic and Volatile Matters, ...	241·78	399·00
INSOLUBLE MATTERS—		
Phosphate of Lime, ...	32·21	
Sulphate of Lime, ...	15·58	
Lime, ...	69·87	
Magnesia, ...	9·18	
Oxide of Iron, ...	31·39	
Alumina,...	99·65	
Silica, ...	271·38	
Organic Matter, ...	633·44	
		1162·70
Total Solids by evaporation, ...		1561·70

Ammonia, free or saline, ...	9·3	Grains per Gallon.
Do. Albuminoid, ...	1·4	,, ,,
Oxygen required to Oxydize the Organic Matter in the filtered Sewage, ...	5·7	,, ,,
Nitrogen in insoluble position, ...	18·55	,, ,,
Equal to Ammonia producible, ...	22·52	,, ,,

This sample of Sewage was probably taken at the worst period of the day, as it is extraordinarily foul.

BRADFORD EFFLUENT. Bradford effluent.

	Ordinary, including manufacturing refuse.		When works are stopped.
Carbonate of Lime, ...	34·30	...	22·05
Carbonate of Magnesia, ...	10·57	...	·72
Sulphate of Lime, ...	15·68	...	10·40
Sulphate of Magnesia, ...	7·35	...	3·78
Chlorides of Sodium and Potassium, ...	7·98	...	6·67
Alumina, &c., ...	1·05	...	1·05
Silica, ...	·35	...	·77
Organic and Volatile Matter, ...	5·67	...	6·16
Total Solids, ...	82·95	...	51·60
Ammonia, free or saline, ...	·56	...	·28
Do. equal to Nitrogen combined in other forms, ...	·28	...	·21
Oxygen required to oxydize organic matter and nitrites, ...	·98	...	·52

Bradford continued.

Both effluents contain a considerable quantity of nitrites, which accounts for the amount of free ammonia being comparatively small. They are almost colourless, and have no appreciable odour. On free exposure to the air carbonate of lime settles out, showing that most of the lime represented above as carbonate, and obtained in that form on evaporation, exists originally in the effluent as free or caustic lime.

Just before the sewage passes into the works, it flows slowly through long and rather narrow tanks, which are used intermittently, and where it deposits its grosser particles, chiefly siliceous matters from the washing of the streets. The tanks are cleaned out periodically, and the siliceous residuum is used for levelling up the land in the vicinity of the works. The sludge which collects at the bottom of the tanks is drawn off by a valve on the level of the floor into a subterranean culvert, which leads to one or other of two large reservoirs situated at the extreme ends of the building. From these reservoirs it is pumped into 20 tanks underneath the building, where it is further settled, and afterwards removed, and either allowed to dry in the open air, or desiccated by artificial heat. It is not considered to possess value sufficient to defray the cost of drying. The following is Dr. Wallace's analysis of the sludge:—

Analysis of sludge.

BRADFORD SLUDGE (AIR-DRIED).

Water at 212° F., ...	8·90
Organic Matter and Combined Water, ...	33·75
Phosphate of Lime, ...	1·74
Sulphate of Lime, ...	1·09
Carbonate of Lime, ...	23·93
Lime, ...	2·11
Magnesia, ...	1·66
Oxide of Iron, ...	2·11
Alumina, ...	3·49
Silica and undecomposed Clay, ...	21·80
	100·58
Nitrogen, ...	·62 per cent.
Equal to Ammonia, ...	·76 ,,
Calculated Value per Ton, ...	15s. 1d.

Halifax.

III. HALIFAX is a town of 68,500 inhabitants, and occupies an area of 3768 acres, giving a density of population of 18 to the acre. The annual average mortality, 1871-5 inclusive, is 26·6 per 1000. It is stated to contain 2000 water-closets, and about 3300 dry closets. The sewage amounts to two and a half million gallons, and it is carried in a culvert parallel to the small beck or burn which runs through the valley in which the town is situated, and admitted into the stream at a point about a mile from the town. Formerly lime was used to defacate the sewage, but now no attempt

is made at purification. The stream which receives the sewage is itself very dirty, and looks quite black.

Halifax—The Goux system.

The Goux system, as it is called, is here adopted for the dry closets. The tubs are of wood, about 16 inches high and 20 inches wide at the top. They are lined with a mixture of street sweepings, fine ashes, shoddy, tow, and sawdust, or any absorbent material that can be procured at little or no cost. A little is put at the bottom, then a mould of 15 inches diameter, and provided with a handle at the top, is inserted, and around this the absorbent material is packed, after which the mould is withdrawn and replaced by a thin sheet iron cylinder. It is stated that a man can pack 80 tubs in an hour. The centre cylinder is not removed until the tub is put in position. On removing the tubs, when full, a little charcoal, soot, or gypsum, is placed on the top, but there are no covers to the pans. The system was originally worked by the Goux Company for five years, at the rate of 7s. 6d. per closet per annum, and then 12s. 2d. per closet, including the collection of the ashes. It was afterwards found that the Company was losing heavily, and a demand was made for 21s. per closet, but this not being conceded, the whole plant of the Goux Company was purchased for £3500 by the Corporation, who now carry on the operations by their own men and horses, under the superintendence of the sanitary inspector of the borough. The average cost is 20s. each closet per annum.

Requires constant supervision.

The Deputation visited the depot, and were somewhat disappointed with the strong odour pervading all parts of it, and the general want of cleanliness. Information obtained from the Borough Surveyor, Mr. R. S. Escott, was to the effect that the system requires very constant supervision, and that there is a good deal of difficulty in disposing of the manure, which brings little more than the cost of carriage. It is conveyed away by canal boats, sometimes to a considerable distance. The night-soil mixed at the depot with fine ashes brings 2s. 6d. per ton, and the street sweepings about 6d. per ton.

Sanitary results satisfactory.

Sanitarily the system has effected an immense improvement, the number of cases of enteric fever having diminished in a constant ratio, as the old privies were gradually replaced by those on the Goux system. Dr. Haviland, medical officer of health, Northampton, has made a special study of the sanitary effects of this substitution, and shows that not only the fever death-rate, but also the general mortality, has decreased in a very marked degree since the change was effected.—*Vide* Society of Arts Conference Report, page 92.

Croydon.

IV. Croydon is a prettily situated town, about 10 miles south of St. Paul's, London. The urban sanitary district, including the whole of Croydon Parish, has a population of 63,000, and occupies a space of 10,000 acres, giving a density of population of 6·3 per acre.

Croydon—Irrigation.

The average annual mortality (1871-5) is 19 per 1000. The rain-fall is 26 to 30 inches, and the water supply amounts to 50 gallons per day per head of population, the source of supply being a deep well in the chalk formation. The sewage, in dry weather, amounts to 2½ million gallons per day, and the number of water-closets is about 15,000. This is a large number of closets for the population, but many of the houses are of a superior class, and have three or four closets. The whole of the sewage is disposed of by irrigation in two farms—the Beddington farm of 465 acres, receiving the sewage of Croydon, while the Norwood farm of 62 acres, receives that of South Norwood. The Beddington farm lies to the west of the town, the nearest point being about a mile distant. The ground slopes very gently towards the west, and the soil is light and porous, with a gravelly subsoil, which renders it unnecessary to drain the ground in the ordinary manner. In fact, it is impossible to imagine a place better adapted by nature for a sewage farm.

Solid matter removed.

The sewage is first passed through a wheel fitted with wire gauze sieves (the invention of Mr. Latham), by which the solid matter is removed, and which is afterwards mixed with sifted ashes and other refuse matters, and made into a manure which sells readily at 4s. 6d. per ton. About a ton of this mixture is produced daily. The sewage then passes on by gravitation to the farm, where it is distributed by open cuts. The fields are flushed by stopping up the subsidiary channels with wooden boards. The effluent is collected in deeper cuts and eventually runs into the Wandle, a small but pretty stream. The condition of the effluent is everything that could be desired: it is perfectly clear and colourless, and no sewage plants were observed in any of the conduits. Cattle are said to drink it freely. No serious difficulty arises during frosty weather, as the sewage retains sufficient heat to get below the layer of ice and percolate through the soil.

Effluent highly satisfactory.

Crops raised.

The crops grown consist of rye-grass, wheat, potatoes, mangel-wurzel, and turnips. One half of the ground is changed every year, but rye-grass is usually kept in for two or three years. Although the ground is not naturally of high quality, excellent crops are raised, as much as £40 per acre having sometimes been obtained for the various crops of rye-grass taken off during the season.

Proximity of houses.

There are very few houses near the farm, but Beddington Manor, which is now occupied as an orphanage, with about 150 children, is close beside it, and the inhabitants do not complain of any bad odour from the fields or conduits. Financially, however, the farm is not a success, owing to the high price of the ground (from £10 to £12 per acre), the loss last year having been about £1700. For the year ending 29th September, 1876, the loss has been only £1012. Other farmers in the neighbourhood readily obtain ground at £2 per acre, and if the sewage farm ground were held on equally reasonable terms, the balance would probably be on the right side. A sewage farm, even after it has been laid out and levelled, is

High rent paid for ground.

much more costly to work than one conducted on the ordinary system. The number of men employed is much greater, and the ground requires to be more frequently turned up. On the other hand, the crops are often unusually heavy. Beddington is probably the most successful sewage farm in England, but apart from the getting rid of the sewage at a moderate outlay, the utilization of the sewage does not, upon the whole, appear to offer any special advantage, further than the production of a purer effluent than can be obtained by any other means. The Deputation were received at Croydon by Dr. Alfred Carpenter, chairman of the farm committee of the local board, who showed them every attention, and communicated the fullest information upon the sewage farming operations. Croydon continued.

V. London.—Population, 3,500,000; density per acre, 45·7; annual mortality, 22·9. The disposal of sewage in London is effected by running it down both sides of the Thames, in culverts of large dimensions, and admitting it into the river at Beckton, on the north side, and Crossness on the south, these places being about twelve miles down the river from the centre of the city. The sewage is not run continuously into the river, but only for three hours during each tide, beginning with high-water and continuing for the first three hours of ebb-tide. The flow of the tide is much more rapid on the Thames than on the Clyde, and the rise and fall much greater; and the object sought for, and which appears to be obtained, is to carry off the sewage by the ebb-tide, to such a distance that it cannot come back with the returning flood-tide. In Glasgow, where the rise and fall scarcely amount to 10 feet, and the scour is comparatively feeble, the same results would not be obtained by engineering works of similar construction.* London.

There is a great Pumping Station for the north side of the river at Abbey Mills, near Stratford, and close to the eastern boundary of the Victoria Park. The sewage comes to this station partly by a high-level culvert, and partly by one at a lower level, and the object of the works at this place is to pump up the sewage from the low to the high level (a height of 36 feet), and so to give it sufficient "head" to carry it to the outfall, a distance of about five miles. The diameter of the main sewer is 12 feet 6 inches, and of the low-level sewer 10 feet 6 inches. There are eight pumping Pumping station at Abbey Mills, near Stratford.

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* The following information has been kindly communicated by Mr. Deas, C.E., Engineer to the Clyde Trust:—"The average range of spring-tides in Glasgow Harbour is 10 feet 6 inches, and of neap-tides 9 feet. The velocity of ordinary spring-tides is—flood 3 furlongs, and ebb 3½ furlongs per hour. That of average neap-tides is—flood ½ furlong, and ebb 1 furlong per hour. Range of tides at Glasgow

"The average range of spring-tides at London Docks is 20 feet 8 inches, and of neaps 14 feet: the mean range is 18 feet. The velocity of flood tides is from 1¾ to 2 miles, and of ebb tides 2¼ to 3¼ miles per hour." and London.

London continued—The pumping station.

engines, each of 142 horse power, but these are rarely all used, the average number in use being four or five. The average number of strokes per minute is ten, and each engine raises 1257 gallons, or about 200 cubic feet, at each stroke. Taking five as the average number of engines at work, the ordinary quantity of sewage pumped daily from the low to the high level will be, almost exactly, 9 million gallons. Those who have seen this magnificent pumping station will be able to form some idea of the stupendous work that would be required to raise the sewage of Glasgow to a height sufficient to admit of its flowing by gravitation to the Ayrshire coast. The quantity of coal required at the Stratford station is 11,000 tons per annum, and the average price about 17s. per ton. There are sixteen boilers, but only eight usually in use. Before going to the pumps, the sewage passes through iron cages for intercepting solid substances which might injure the machinery. About three loads of old corks are collected daily.

Outflow of sewer.

From the Stratford station the high-level culvert goes, in a nearly strait line, E.S.E., crossing Barking road, to the outflow works just beyond the Beckton Gas-works. The sewage is not discharged into the river, but into a reservoir having an area of 10 acres, 14 feet high, and roofed over and covered with vegetation. From this reservoir the sewage is discharged into the river as already stated.

The Lodge farm, Barking.

Near the outflow works is a culvert leading a portion of the sewage, when required, northward to Barking, where a sewage farm has been in operation for several years, and had been discontinued only a week or so at the time of the visit of the Deputation. The Lodge farm has a total area of 212 acres, but the whole of the land has never been under sewage. The greatest area treated by irrigation was 190 acres in 1872, while last year the acreage had decreased to 71½. The quantity of sewage used was about 600,000 tons, the average per acre varying from 3300 tons in 1872, to 8500 tons in 1875. To pump the sewage, averaging about 368,000 gallons per day, to a height varying from 35 to 40 feet, through a main a little over a mile and a half in length, cost £450 per annum, without allowing anything for depreciation of machinery. For two years, when the land was new, a profit was made; but during the last four years there has been a considerable loss over and above the cost of pumping, which is not included in the accounts of the farm. Upon the whole, the Lodge farm has been a conspicuous failure, and after a fair trial of about seven years, the use of sewage has been finally abandoned. Mr. Morgan, the manager, gave valuable information to the members of the Deputation who visited the farm.

Crossness outfall works.

On the south side of the river there are works at Crossness, near Woolwich Arsenal, similar to those on the north bank. These were also visited, but a detailed description of them is not required.

VI. Birmingham.—This town, with a population of 375,000, occupies an area of 8420 acres, has a density of 44·5 persons to the acre, and an average death-rate of 25·2. The water gives 17·8 grains of solid residue per gallon, and the hardness is 11·7 degrees. The water department pump up about 8 million gallons per day, but there are also numerous wells supplying public buildings and private houses. The number of water-closets in 1872 was 7065, but, although the population has largely increased since that time, the number of water-closets is now only 7514. In fact, the use of these is discouraged by the municipal authorities, although not absolutely forbidden. When the plans of a house or tenement of houses of the smaller class are submitted to the Borough Surveyor, he practically refuses to pass them, although without legal powers, unless proper provision is made for carrying out the dry-closet system. The number of houses in 1871 was 75,000, and since that time 8420 have been erected, bringing up the present number to 83,420. The number of pan-closets in use at 31st December, 1876, was 17,000, all the new houses of the smaller class being fitted with these—one closet serving for not more than two houses. Of ordinary privies there were, at the same date, 27,436, and of ashpits 19,154. Birmingham.

The sewage of Birmingham contains the drainage from the 7514 water-closets mentioned above, the house-slops from the entire town, and a very considerable amount of manufacturing refuse, some of which has an acid reaction. The quantity of sewage is from 12 to 16 million gallons per day, and the treatment it receives before being passed into the river Tame and its tributary, the Rea, consists in the addition of lime and subsequent precipitation. The quantity of lime used averages 13 tons a day, and the cost of the lime is 15s. per ton. The sewage works, which are situated at Saltley, on the N.E. side of the town, occupy, including tanks, roads, &c., about 50 acres; but the whole extent of ground belonging to the Corporation is 265 acres, the greater part being used for farming operations, as will be described further on. The lime, not ground as at Bradford, but slacked, is mixed with the sewage in a building about a quarter of a mile from the precipitation tanks; and no pumping is necessary except what is required to raise enough sewage to mix with the lime The sewage is now allowed to fall into one of two tanks of large dimensions, which are used alternately, each for 14 days, and in these the greater part of the sludge precipitates. The partially settled effluent is next passed through a series of shallower tanks of considerable area, of which there are 32 in all, one-half being of smaller size than the others, and divided into two sets, which may be used alternately, if required. As there is a constant flow of water in all these tanks, the precipitate does not settle so readily as it does at Bradford, where, after the lime is added, the mixture is left at rest for thirty or forty minutes. Another evil arises from the putrefaction of Treatment of the sewage.

Birmingham continued.

the sludge in the tanks furthest removed from the inlet of the sewage. In these the sludge collects so slowly that it may accumulate for months, and in course of time it begins to ferment and throw up bubbles of gas. There is nothing of this sort at Bradford, where the sludge is removed from each tank as soon as the supernatant water is removed, and collected in special receptacles for settling and solidification. The effluent, however, appears to be sufficiently free from sedimentary matter, although not so clear as at Bradford. In the Birmingham works there is no filtration of the effluent through "breeze," or other purifying medium, the water passing at once from the last settling-pond of the series into the Tame on one side, and the Rea on the other. It has a slight but distinct alkaline reaction, has no appreciable odour, and is only slightly coloured. The operations of the sewage works, so far as the effluent is concerned, are fairly satisfactory.

Disposal of sludge.

The disposal of the sludge is a very important department of the works. A small quantity of it has been mixed with an extra quantity of lime, dried and burnt, and ground into a kind of Portland cement, according to General Scott's patent; but the bulk of it has hitherto been used on the farm of about 200 acres connected with the works. It is removed from the tanks in a soft creamy condition, and pumped up to a height of about 10 or 12 feet above the level of the ground into a wooden trough about 30 inches wide and 18 inches high. Men walk in this trough, pushing forward the semi-solid sludge by means of wooden boards fixed on long poles. The troughs are carried temporarily wherever they are wanted, and are supported on wooden trestles placed about 12 feet apart. The mode of putting it on the ground is something like the following:—A piece of ground of a few acres is selected, the turf is removed from the surface, and used for building walls, about 2½ feet high, in such a way that the whole field is divided into square plots or rooms, about 12 yards square. The sludge is now run into these rectangular spaces to the height of 2 feet, and, after it has solidified sufficiently, the process is repeated, and afterwards the whole field is trenched, and the sludge covered up by the natural soil. The ground thus prepared yields excellent returns; large crops, especially of mangel-wurzel and turnips, having been obtained. The cost of digging in the sludge is £14 5s. per acre, and the making of the turf walls, 2d. per lineal yard, or about £7 per acre. The ground is ready for a repetition of the process after three or four years. The quantity of wet sludge is stated to average 360 cubic yards, or about 288 tons daily, and it contains from 80 to 90 per cent. of water. Owing to the existence of a large extent of macadamized roads in the town, a large quantity of siliceous matter is carried by the drains, and greatly increases the quantity of sludge. 120 men are engaged on the works and farm. The erection of sewage works, tanks, and buildings, cost about £51,000, which, considering the great extent of the works

appears to be a moderate outlay. 160 acres of freehold land cost £50,000, and the remainder is leased at about £7 per acre. The annual expense of the sewage works and farm, after deducting income for manure and farm produce, is about £12,000. Birmingham continued.

The Rochdale system of pails for night-soil, and tubs for ashes, is carried out at Birmingham. About 17,000 pans are now in use, and at the depots (of which there are two) the pans, after being emptied of their contents, are washed before being sent out again. All the manure is despatched by canal. The quantity of ashes, &c., sent to the country during the year 1875 was 112,000 cart loads, or nearly 130,000 tons. Disposal of night-soil.

In one part of the precipitation works a small building has been erected for the purpose of testing on a practical, although small, scale the process of General H. Y. D. Scott, for dealing with that portion of town excreta which is collected in pails, the works being constructed to work the contents of about 500 pails weekly. Means are adopted to coagulate the greasy matters and to render the solids porous, so that the more liquid portions can readily be separated from them, while the alkali (magnesia) added facilitates the distillation of the ammonia, which is collected in sulphuric acid, and then crystallized out as a sulphate. The heat which is necessary to bring over the ammonia also assists in the coagulation of the greasy matters. The separation of the ammonia is continued until the strength of the liquid is so reduced that the process would no longer be remunerative; and phosphoric acid, which combines with the magnesia previously introduced is added, forming a phosphate which fixes the remainder of the ammonia and assists in rendering the solids friable and inoffensive. The solid portion is then dried, and constitutes a manure of considerable value, which may be improved by the addition of the sulphate of ammonia. The works had been in operation for only a few weeks at the time of our visit. General Scott's system for treating the excreta collected in pails.

VII. Coventry.—The Coventry urban sanitary district, which includes this very interesting little city, has a population of 40,000, and an average annual mortality of 23·4 per 1000 (1871-5 inclusive). The population per acre is 10. The water supply is obtained from four artesian wells, sunk in the new red sandstone. The present number of water-closets is about 5000, and of privies, 800. The sewage works are situated about a mile from the town, and the effluent goes into a small stream called the Sherbourne. So far back as the year 1850, Coventry was compelled to take steps to improve its sanitary condition; and the system of sewers with an outfall into the Sherbourne was completed in 1854. The stream immediately became so foul that in 1857 it was resolved to erect filtering tanks. These were completed a year afterwards, and the sewage was then passed through filters containing about 3 feet of coarse gravel. Not much benefit was derived from this treatment; Coventry.

Coventry continued.

and as the quantity of sewage gradually increased, the complaints of the landowners along the course of the Sherbourne became more and more clamant, and various schemes of purification were proposed and subsequently abandoned, until in 1872 the General Sewage and Manure Co., who had purchased the patent of Dr. Anderson, made arrangements with the Corporation, who granted a concession of the sewage to the Company for a term of 20 years. The works were completed in 1874 and cost £14,000, but already the Company has succumbed to adverse circumstances, and have disposed of the works to the Corporation for £3000, and they are now carried on at a yearly expenditure of about £2700.

Treatment of sewage by crude sulphate of alumina.

The quantity of sewage is calculated to be $2\frac{1}{4}$ million gallons per day. On entering the works it is first passed through Latham's wheel filter, in order to separate the floating solid matter, of which from 2 to 6 cwt. per day is obtained. It then receives an addition of a solution of sulphate of alumina (made in the works by the action of sulphuric acid upon ground shale), and further on lime is added in quantity just sufficient to precipitate the alumina. The quantities of these materials used daily are 2 to $2\frac{1}{2}$ tons of the crude sulphate of alumina, and 10 to 15 cwts. of lime. The mixture passes into large precipitation tanks, of which there are four, and which are used alternately; and the effluent, after settling, is filtered through 9 acres of land, thoroughly drained, of which one-half is used alternately with the other. The operations are quite successful in producing an excellent effluent.

Treatment of sludge.

The sludge is first strained of a large proportion of its water by Milburn's continuous automatic filter, and then partially dried by heat in Milburn's patent drying machine; after which the completion of the drying process is effected by simple exposure in heaps to the air. There is little or no demand for the dried sludge, but it has been used to a small extent as the basis of, or an addition to, various artificial manures.

Manchester.

VIII. Manchester.—This important city has a population of 356,000, and the average death-rate during the last five years was 30. The number of persons to the acre is 83·1. The river Irwell separates it from Salford, which has a population of 136,000, a death-rate of 29·3, and a density of population of 26·3 per acre. The river, when in flood, frequently overflows its banks, and does considerable damage to property.

Sewage runs into the Irwell without purification.

Like Glasgow, Manchester has not yet adopted any system for the disposal of its sewage, which is permitted to run into the Irwell without any attempt at purification. A scheme for dealing with the sewage, and at the same time preventing the river from overflowing its banks, has been proposed; but the matter is still under consideration, and it is not expected that anything will be done for several years. There are comparatively few water-closets in Manchester, and they are discouraged as much as possible, and practically forbidden in

houses of the smaller kind. There are 42,000 privies, and these are gradually being altered into pan-closets. Already 24,000 have been thus converted, and Dr. Leigh, the medical officer of health, expects that in three years the whole will have been altered. The system of conversion is the following:—The privy is removed and the ground upon which it stood, and which is necessarily saturated with filth, is dug up to the depth of several feet, and carted away, and the space filled in with clean furnace ashes. Upon this the privy, with compartment for cinders, is built, and the whole roofed over. The cost of each privy is £4 4s. when erected by the workmen belonging to the Corporation, who charge the owner of the property the nett outlay. The pails are constructed of galvanized iron, and are made and, when necessary, repaired at the Corporation depot in Water Street. Attached to each closet is a cinder-sifter, and the fine cinders and ashes mix with the excreta, and make it more manageable than it would be in its pure state. Separate tubs are used for the coarse cinders and general refuse of the houses. Dr. Leigh calculates that when all the privies are converted, 6,000,000 gallons of urine annually will be kept out of the sewers, and consequently out of the Irwell, that were formerly allowed to flow into it. The old system privies are emptied during the night, but the pan-closets are removed during the day—vans specially constructed for the purpose being used. They have five compartments, one of which is open and uncovered, and this receives the dry refuse; the other four are covered and enclosed with closely-fitting doors. Each of these compartments holds six pails, which are also covered with closely-fitting lids. Sixty-five waggons are now in use, and each makes four journeys daily. About 3000 tons of material are dealt with weekly, and these consist of—paper, 1 ton; rags, 3 tons; dead animals, 2 tons; stable manure, 2 tons; old iron and tin-plate, 33 tons; refuse from slaughter-houses and fish-shops, 60 tons; broken pottery, earthenware, and glass, 80 tons; vegetable refuse, door-mats, table-covers, floor-cloths, old straw mattresses, &c., 100 tons; fine ashes, 1230 tons; cinders, 1400 tons. Over 400 men are employed, including clerks, inspectors, wheelwrights, smiths, saddlers, tinsmiths, engineers, mechanics, manure and mortar makers, stable-men and labourers. They have 130 horses, and about the same number of carts of various descriptions. When the loaded vans reach the yard, they are first weighed, afterwards they are taken on to the first floor of a two-story building, where the dry refuse from the open part of each van is unloaded, and shovelled into sieves worked by steam power. By this arrangement the fine dust, widely diffusing itself in its descent, falls on the floor below, covering the contents of the pails, which are, at the same time, being emptied on to gratings fixed in the floor. At one end the bars are set much more closely together than at the other, and serve to convey the liquid portion

Manchester continued.

Conversion of privies into pan-closets.

Refuse of the City.

Manchester continued.

of the contents of the pails by means of troughs to a tank, from which it is afterwards removed to an apparatus called a concretor. The solid portion of the excreta falls through the wide barred portion of the grating into suitable receptacles. The rough portion of the dry refuse, after being separated from the fine, is carried along an endless band of wooden bars to the mortar mills, the boiler, or to one of the various furnaces, of which there are several in the yard. The dry refuse is of such a heterogeneous character as to require varied modes of treatment. The cinders are separated and used for fuel for the boilers and furnaces (no coal whatever being allowed in the yard); the remaining portion of the rubbish is taken to the carbonizers (of which there are eight), and the material, often of an obnoxious description, is therein carbonized and converted into a harmless and useful substance. In another part of the yard is a second set of furnaces, called destructors, which are used for the purpose of destroying rubbish which formerly had been deposited in large heaps in every suburb of the city. These destructors not only consume the objectionable material, but furnish heat to the concretors, large cylinders laid horizontally, and revolving by steam power, in which the liquid of the pails (chiefly urine) is evaporated to one-tenth of its bulk, and afterwards formed into a valuable manure by being mixed with two-thirds of its weight of charcoal from the carbonizers. The spent fuel is carted to the mortar mills, and there ground up with broken earthenware and glass, fine ashes, and lime, to form a most excellent mortar, which contains one-third of its weight of lime, and sells readily at 4s. 6d. a ton. 400 tons of manure are made weekly, and sold at 12s. 6d. per ton. The carbonizer, the destructor, and the concretor, have all been invented and patented by Mr. Alfred Fryer, formerly sugar refiner in Manchester, now of the firm of Manlove, Alliot, and Co., engineers, Nottingham. Some of the above details are taken from a paper in the "British Architect" for 29th September, 1876.

Operations conducted in the refuse depot—the carbonizer, destructor, and concretor.

Oldham.

IX. Oldham.—This was the last place visited by the Deputation. It is a purely manufacturing town, having a population of 88,000, and an annual mortality of 28·2: the density of the population per acre is 18·7. The pail system is in general use, and the contents are taken by the Carbon Fertilizer Company, who have purchased the patent of Mr. E. C. C. Stanford for absorbing excrementitious matter by charcoal, and afterwards drying and carbonizing the mixture; thus giving rise to a continually augmenting quantity of animal charcoal, which may be employed in the manufacture of manures, and for other purposes. The principal product of the destructive distillation is ammonia. Unfortunately this patent does not appear as yet to have had a fair trial. The Oldham works, at the date of the visit, were in a state of apparently inextricable confusion, and it was impossible to form any idea of the merits or demerits of the system.

The Carbon Fertilizer Company.

Glasgow.—The following statistics relating to our own city will be useful for comparison :—The estimated population in 1875 was 534,564, and the average mortality (1871-5) was 29·9. The area of ground occupied is 6034 acres, giving an average density of 88·6 persons to the acre. The number of dwelling-houses in 1874 was 101,368, and of shops, warehouses, and factories, 16,218; the water-closets numbered 31,927; sinks, 71,291; fixed basins, 3865; and urinals, 211. There are also, at the present date, 6751 dry ashpits, 1395 middens or wet ashpits, 3816 pan closets, 94 trough closets, chiefly in public works, and 13 public conveniences, 7 of which are fitted with pans, and 6 with Macfarlane's patent troughs. 109 manufactories discharge refuse of various kinds into the sewers; and there are 2304 stables with 7024 horses, and 311 cow-houses with 1350 cows. In addition to the factories, the refuse of which is conveyed into the drains, 20 discharge direct into the river. The length of the sewers is about 100 miles. Within the city boundary there are at present 131½ miles of paved streets, 20½ miles of statute labour roads, and 10 miles of turnpike roads—in all, 162 miles. Glasgow

The estimated volume of the whole discharge into the river daily is 40 millions of gallons, exclusive of rain-fall, but including the water of the Molindinar and other burns. The average rain-fall (40 inches in the year), if there were no evaporation from the ground, would be nearly 15 million gallons per day, giving a total average of 55 million gallons per day. The volume of the River Clyde at Glasgow, in ordinary circumstances, was estimated by Mr. Ure, C.E., formerly engineer to the Clyde Navigation, at 48,000 cubic feet per minute, which is equal to 432 million gallons per day; so that the sewage and drainage of Glasgow adds, at most, about one-eighth to the volume of the river. In very wet weather the flow of the river must be something like ten times the above quantity. Sir John Hawkshaw makes provision for a fall of one-quarter of an inch of rain in 24 hours during wet weather, any quantity above this being considered storm water to be carried off by special sewers into the Clyde. A quarter of an inch of water upon a surface of 6034 acres is equal to 152,358 tons, or, in round numbers, 34 million gallons. The total quantity of sewage in wet weather would therefore be about 74 million gallons per day, and in dry weather 40 million gallons. If a separate system of drains for sewage were adopted, the rain-fall and manufacturing refuse being carried direct into the river, the quantity would be about 30 million gallons per day, with very little variation throughout the year. Volume of Sewage and of the River.

Mr. J. M. Gale, C.E., engineer of the Corporation Water-works, states that during 1876 the quantity of water sent into the city and suburban villages averaged 33 millions of gallons per day. It was distributed to a population of 710,000, so that the volume of water per head was 46½ gallons per day, being a reduc- Water Supply.

Glasgow continued.

tion of about 6 gallons as compared with the previous year. It is estimated that 14 gallons are used in manufactures and for general trade purposes, leaving for the actual domestic consumpt 32½ gallons per head. Mr. Gale estimates that by further improvements in the distributing plant and house fittings the figure may ultimately be reduced to 20 or 25 gallons. The population supplied by the Glasgow Water-works has doubled since 1833, and if a similar rate of increase continues, we shall require 55 to 60 million gallons per day by the end of the century.

Drainage Area of the Clyde.

According to Sir John Hawkshaw, the area draining into the Clyde above Gourock is 1481 square miles. The tidal portion of the river receives four principal tributaries—the Leven, Black Cart, White Cart, and Kelvin. The area drained by these tributaries is 632 square miles, and the population of the towns and villages situated upon them was, in 1871, 128,000. The population of Glasgow, including the suburbs of Partick, Hillhead, Springburn, Govan, Kinning Park, Crosshill, Pollokshields, Strathbungo, Mount Florida, Crossmyloof, Shawlands, and Rutherglen, was, in 1871, 569,000. The population of the towns and villages on the Clyde below Glasgow, including Renfrew, Duntocher and Faifly, Old Kilpatrick, Helensburgh, Port-Glasgow, Greenock, and Gourock, was, at the same date, 87,600; and on the Clyde above Glasgow, including Lanark, Hamilton, &c., 34,400. The tributaries above Glasgow are the Rotten Calder, North Calder, South Calder, Cadzow, Douglas, Nethan, and Elvan; and these have towns and villages upon them having an aggregate population of 90,000. The total population in 1871 was 909,000, and it may now be safely assumed to be, in round numbers, 1,000,000.

NOTE.—Since the above was in type, Mr. Gale, engineer to the Glasgow Corporation Water-works, has issued his fourth quarterly Report for 1877, in which he makes the following remarks:—

"As an evidence of the extent to which all modern conveniences are being introduced into dwelling-houses, I may mention that, during the past year, 7486 water-closets and 393 urinals have been put up in new houses. In 1864 an enumeration of the water-closets within the area of supply was made, when the number was found to be 28,054. Since that time the increase has been very great, and the number of these appliances must now approach 100,000."

It will be observed that these statements refer, not to the Municipality of Glasgow, but to the whole area of water supply, the estimated population of which, in April, 1877, according to the books of the Water Trust, was 730,000. The statistics show very clearly how much the suburban population is adding, year by year, to the pollution of the river.

APPENDIX No. 2.

Report to Local Government Board on Sewage

The following are the conclusions of the report of the Committee appointed by the Local Government Board to inquire into the several modes of treating town sewage:—

1. That the scavenging, sewering, and cleansing of towns are necessary for comfort and health; and that, in all cases, these operations involve questions of how to remove the refuse of towns in the safest manner and at the least expense to the ratepayer.

2. That the retention for any lengthened period of refuse and excreta in privy cesspits, or in cesspools, or at stables, cowsheds, slaughter-houses, or other places in the midst of towns, must be utterly condemned; and that none of the (so-called) dry earth or pail systems, or improved privies can be approved, other than as palliatives for cesspit-middens, because the excreta is liable to be a nuisance during the period of its retention, and a cause of nuisance in its removal; and, moreover, when removed leaves the crude sewage, unless otherwise dealt with by filtration through land, to pollute any water-course or riverinto which such sewage may flow. We have no desire, however, to condemn the dry earth or pail systems for detached houses or for public institutions in the country, or for villages, provided the system adopted is carefully carried out.

3. That the sewering of towns and the draining of houses must be considered a prime necessity under all conditions and circumstances, so that the subsoil water may be lowered in wet districts, and may be preserved from pollution, and that waste water may be removed from houses without delay, and that the surfaces and channels of streets, yards, and courts may be preserved clean.

4. That most rivers and streams are polluted by a discharge into them of crude sewage, which practice is highly objectionable.

5. That, as far as we have been able to ascertain, none of the existing modes of treating town sewage by deposition and by chemicals in tanks appear to effect much change beyond the separation of the solids, and the clarification of the liquid. That the treatment of sewage in this manner, however, effects a considerable improvement, and when carried to its greatest perfection, may in some cases be accepted.

6. That, so far as our examinations extend, none of the manufactured manures made by manipulating towns' refuse, with or without chemicals, pay the contingent costs of such modes of treatment; neither has any mode of dealing separately with excreta, so as to defray the cost of collection and preparation by a sale of the manure, been brought under our notice.

7. That town sewage can best and most cheaply be disposed of and purified by the process of land irrigation for agricultural purposes, where local conditions are favourable to its application, but that the chemical value of sewage is greatly reduced to the farmer

by the fact that it must be disposed of day by day throughout the entire year, and that its volume is generally greatest when it is of the least service to the land.

8. That land irrigation is not practicable in all cases; and, therefore, other modes of dealing with sewage must be allowed.

9. That towns situate on the sea coast, or on tidal estuaries, may be allowed to turn sewage into the sea or estuary below the line of low-water, provided no nuisance is caused; and, that such mode of getting rid of sewage may be allowed and justified on the score of economy.

ROBERT RAWLINSON.
CLARE SEWELL READ.

24RD JULY, 1876.

APPENDIX No. 3.

Society of Arts Conference on Sewage, 1876.

Conclusions adopted by the Chairman and Executive Committee of the Conference on the Health and Sewage of Towns, held at the Society of Arts, London, 9th, 10th, and 11th May, 1876.

The Chairman of the Conference and the Executive Committee, after having carefully considered the information furnished from the various localities, as well as the facts brought forward during the Conference, have to submit the following as the conclusions to which such information appears to lead :—

1. In certain localities, where land at a reasonable price can be procured, with favourable natural gradients, with soil of a suitable quality, and in sufficient quantity, a sewage farm, if suitably conducted, is apparently the best method of disposing of water-carried sewage. It is essential, however, to bear in mind that a profit should not be looked for by the locality establishing the sewage farm, and only a moderate one by the farmer.
2. With regard to the various processes based upon subsidence, precipitation, or filtration, it is evident that by some of them a sufficiently purified effluent can be produced for discharge, without injurious result, into water-courses and rivers of sufficient magnitude for its considerable dilution; and that for many towns, where land is not readily obtained at a moderate price, those particular processes afford the most suitable means of disposing of water-carried sewage. It appears, further, that the sludge, in a manurial point of view, is of low and uncertain commercial value; that the cost of its conversion into a valuable manure will preclude the attainment of any adequate return in the outlay and

working expenses connected therewith, and that means must therefore be used for getting rid of it without reference to possible profit.

3. In towns where a water-carried system is employed, a rapid flow, thorough ventilation, a proper connection of the house drains and pipes with the sewers, and their arrangement and maintenance in an efficient condition, are absolutely essential as regards health; hitherto sufficient precautions have rarely been taken for efficiently ensuring all the foregoing conditions.
4. With regard to the various dry systems, where collection at short intervals is properly carried out, the result appears to be satisfactory, but no really profitable application of any one of them appears as yet to have been accomplished.
5. The old midden or privy system in populous districts should be discontinued, and prohibited by law.
6. Sufficient information was not brought forward at the Conference to enable the Committee to express an opinion in regard to any of the foreign systems.
7. It was conclusively shown that no one system for disposing of sewage could be adopted for universal use; that different localities require different methods to suit their special peculiarities; and also that, as a rule, no profit can be derived at present from sewage utilization.
8. For health's sake, without consideration of commercial profit, sewage and excreta must be got rid of at any cost.

The Executive Committee, whilst abstaining from submitting any extensive measures, have no hesitation in recommending that the prevention of dangerous effects from sewage gases should receive the immediate attention of the Legislature, and they submit the following resolutions as the basis of petitions to Parliament :—

1. That the protection of public health from typhoid and other diseases demands that an amending Act of Parliament be passed as soon as possible, to secure that all house drains connected with public sewers in the metropolis, and towns having an urban authority, should be placed under the inspection of Local Sanitary Authorities, who shall be bound to see to the effective construction and due maintenance of all such house drains, pipes, and connections. Provisions having this object in view already exist in the Act constituting the Commissioners of Sewers in the City of London, in the Metropolis Local Management Act, 1855, and in the Public Health Act, 1875, but practically they seem scarcely sufficient for the purpose.
2. That plans of such drains and connections be deposited in the charge of the respective Local Authorities, who shall be

bound to exhibit them and supply copies of them to the public on payment of a moderate fee.

3. That the owners of houses be compelled by law to send to the respective Local Authorities, within a specified time after the passing of the Act, plans of all house drains on an appointed scale.

Signed by

The Right Hon. JAMES STANSFELD, M.P.,
Chairman of the Conference.

Members of the Executive Committee.

- Lord ALFRED S. CHURCHILL, *Chairman of the Council,*
- F. A. ABEL, F.R.S., *President of the Chemical Society,*
- Sir HENRY COLE, K.C.B.,
- Capt. DOUGLAS GALTON, R.E., C.B., F.R.S.,
- Lieut.-Colonel E. F. DU CANE, R.E., C.B., *Surveyor-General of Prisons,*

APPENDIX No. 4.

Society of Arts Conference, 1877.

Conclusions adopted by the Chairman and Executive Committee of the Conference on the Health and Sewage of Towns, held at the Society of Arts, London, 3rd and 4th May, 1877.

The Executive Committee report that the Conference applied itself especially this year to the dry systems, as distinguished from the water-carried system discussed last year, and have passed the following resolutions thereon:—

1. That the pail system, under proper regulations for early and frequent removal, is greatly superior to all privies, cesspools, ashpits, and middens, and possesses manifold advantages in regard to health and cleanliness, whilst its results in economy and facility of utilization often compare favourably with those of water-carried sewage.
2. That hitherto no mode of utilizing the excreta has been brought into operation which repays the cost of collection.
3. That the almost universal practice of mixing ashes with the pail products, though it applies these as a convenient absorbent, and possibly to some extent as a deodorant, is injurious to the value of the excreta as a manure.

4. That, for use within the house, no system has been found in practice to take the place of the water-closet.
5. That, although there are appliances and arrangements by means of which the sewer-gases may be effectually prevented from entering houses, they still do so in the great majority of dwellings, both in town and country, including the metropolis.
6. That it is of the highest importance, in a sanitary point of view, that the Metropolitan and Local Authorities should exercise great vigilance with respect to this matter, and that it should be made by law the duty of these bodies to enforce efficient measures for the exclusion of sewer-gases from dwellings, and to watch over their being efficiently carried out under such a system of payment as shall not press too heavily on those at whose charge the work is done.
7. That in every large town plans of its drainage should be deposited with the Local Authorities, and be accessible to the public.
8. That all middens, privies, and cesspools in towns should be abolished by law, due regard in point of time being had to to the condition of each locality.
9. That the annual accounts of the Sanitary Authorities, especially in great towns, should be prepared and published in sufficient detail.

Signed by

The Right Hon. JAMES STANSFELD, M.P.,
Chairman of the Conference.

Lord ALFRED CHURCHILL.
Sir H. COLE, K.C.B.
Lieut.-Col. Sir E. F. DU CANE, K.C.B., R.E.
F. A. ABEL, F.R.S.
General F. C. COTTON, R.E., C.S.I.
Captain DOUGLAS GALTON, R.E., C.B., F.R.S.

APPENDIX No. 5.

Cost of Disposal of Sewage.

Comparison of the Cost of disposing of Town Sewage by different processes, in proportion to the Annual Rateable Value, &c., 1875. Compiled from a Table given in the Report of Committee appointed by the Local Government Board, 1876, page lviii.

Name of Town.	Population (about).	Number of Houses.	No. of Water-Closets.	Annual Rateable Value.	Per £ of Rateable Value.	
					Sewage.	Scavenging
BY IRRIGATION.						
1. Banbury,	12,000	3,485	2,485	£34,104	1d.	—
2. Bedford,	18,000	3,500	3,000	65,000	1d.	—
3. Blackburn,	90,000	16,700	730	235,127	8d.	3½d.
4. Cheltenham,	45,000	8,725	8,500	217,849	½d.	¼d.
5. Chorley,	20,000	4,000	200	54,407	4½d.	2½d.
6. Doncaster,	20,000	4,300	—	68,721	3½d.	—
7. Harrogate,	12,000	1,500	1,620	50,000	5¾d.	—
8. Leamington,	24,700	4,500	8,370	113,400	5½d.	1d.
9. Merthyr-Tydvil,	55,000	10,778	8,000	135,000	7½d.	—
10. Rugby,	8,400	1,700	1,400	45,000	1½d.	—
11. Tunbridge Wells,	23,000	5,750	5,635	142,914	10d.	—
12. Warwick,	11,000	2,400	2,000	43,339	6½d.	—
13. Wolverhampton,	71,000	14,000	750	210,000	2d.	1½d.
14. West Derby,	31,400	—	3,220	163,000	4d.	1¼d.
BY LAND FILTRATION.						
15. Kendal,	13,700	2,727	450	£44,600	4d.	—
BY PRECIPITATION.						
16. Birmingham,	350,000	83,420	8,000	1,229,844	4¼d.	5¾d.
17. Bolton-le-Moors,	93,100	18,249	758	311,563	2d.	1½d.
18. Leeds,	285,000	57,000	8,000	945,141	4¾d.	4½d.
19. Bradford,	173,723	34,000	4,050	745,671	3¼d.	2¾d.
BY THE PAIL SYSTEM.						
20. Halifax,	68,000	11,218	2,600	£262,581	—	4d.
21. Rochdale,	67,000	14,388	350	222,000	—	8¾d.